

Two New Species of Fairy Shrimp (Crustacea: Anostraca: Thamnocephalidae: *Branchinella*) from the Paroo, Inland Australia

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ABSTRACT. Two new species of fairy shrimp, *Branchinella budjiti* and *B. campbelli*, are described from intermittent wetlands in northwestern NSW. Both have very distinctive frontal appendages, second antennae and other features that defy classification into established groups within the genus.

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The genus *Branchinella* Sayce, 1903, is one of the most speciose genera of fairy shrimps in the world with 33 species so far described (Belk & Brtek, 1995). Geddes' (1981) review of Australian *Branchinella* recognized 18 species, but Belk & Brtek (1995) elevated three of his subspecies to specific rank, enlarging the Australian fauna to 20 species, all endemic. Forty percent of these are known from a very limited area or just the type locality in the arid zone. It is not surprising then that intensive collecting in one such area, the middle Paroo catchment of northwestern NSW and southwestern Qld, has yielded many new distribution records and two new species (Hancock & Timms, in review; Sanders, 1999; Timms, 1993, 1997). In addition, a new genus in the family Branchipodidae and a new species of *Parastreptocephalus* (Streptocephalidae) have been found (Timms, unpublished data). It is the purpose of this paper to describe the new species of *Branchinella* and to attempt to place them into the groupings of *Branchinella* proposed by Geddes (1981).

Taxonomy

Thamnocephalidae

Branchinella Sayce, 1903

Branchinella budjiti n.sp.

Fig. 1

Type material. HOLOTYPE: ♂, Australian Museum (AM hereafter), AM P58543, length 16.1 mm; ALLOTYPE: 1 ♀, AM P58544, length 13.9 mm; PARATYPES 4 ♂♂ (length 15.9±0.6 mm) and 3 ♀♀ (length 13.3±0.6 mm) AM P58545.

Type locality. An unnamed claypan c. 500 m NW of Muella Station homestead, 130 km NW of Bourke, NSW, 29°31'S 144°56'E, altitude 120 m a.s.l., collected by the author, 6 December 1999.

Other material. 20 ♂♂, 10 ♀♀ from Sues Pan, Bloodwood Station, 132 km NW Bourke, NSW, AM P58546; collected by the author 17 November 1999. Unnamed Yapunyah swamp, 22 km NE of Currawinya homestead on Eulo Rd, Currawinya National Park, Queensland, Queensland Museum (QMB hereafter) W25187; collected by the author 18 May 1996. Collections by author from 18 sites, some at multiple dates during 1988–2000, on Bloodwood, Muella and Tredega Stations, 130–150 km NW Bourke. Collections by author from 28 sites, some at multiple dates during 1987–2000, at Currawinya National Park, via Hungerford, Qld. Collections by author from 5 sites during 1995–2000 on Rockwell Station, 145 km SW of Cunnamulla, Qld.

Etymology. Named in honour of the Budjiti tribe, first human inhabitants of the middle Paroo country.

Description of male

Length 16.1 mm. Cephalothorax slightly longer than the abdomen minus the cercopods. Antenna I reaches a little beyond the apex of the basal segment of antenna II (Fig. 1A). Antenna II (Fig. 1B) basal segment at c. 70° to body axis (instead of c. 20–40° as in typical *Branchinella* species). This segment with two raised pads anterodistally bearing a few short thin setae, and an outgrowth at its posterolateral corner. This outgrowth lamellar, smooth and serrate on the anterior margin and about one third to half the length of the distal segment. Distal segment a little longer than basal segment, sclerotized, flattened and bending medially c. 20°. Medial margin with a medial swelling and bearing small serrations. Apex tapering and truncated.

Frontal appendage (Fig. 1C) large and elaborate, carried curled beneath the thorax and reaching up to half its length and doubling the depth of the thorax. Basal section fused into a trunk bearing three long papillae on the lateral margins. This supports two large wing-like branches, each a little longer than wide and bearing an expanded distal margin, particularly at the posterolateral corners. Numerous papillae on the lateral margins and lower surface; those on a central thickened area underneath each branch longer than the rest, except for c. 7 long papillae on the outer distal corners of each branch. Density of papillae varies, least on the ventral area of the fused trunk and inner area of the branches, and most numerous towards the outer distal corners.

Thoracopods (Fig. 1F) with endopodite smoothly rounded (but first thoracopod has a shallow notch anterodistally) and bearing long setae. On thoracopod 5, but not thoracopods 1 and 11, the bases of the anterodistal region of endopodite with a rounded knob on one side. Endites 1 and 2 very setose and each with an anterior setae, the first about half the length of the second. Endites 3–4 each bear 2 anterior setae and endite 5 bears 1 anterior setae on phylloids 1, 5 and 11. Exite longer than endopodite but narrower and more setose. Epipodite sausage-shaped and smooth. Preepipodite expanded and serrated; no notch on its border.

Penis (Fig. 1D) short, extending back one or at most two abdominal segments when everted. Armed with c. 9 large asymmetrical teeth on the lateral (convex) face and with numerous long papillae on the side and medial (concave) face. These papillae shorter near the distal end. Distal end lobed on the inner curvature and bears a harder asymmetrical tooth on the outer apex. Base of penis bare of teeth or papillae. No swelling lateral to the penes. Cercopods of telson (Fig. 1E) heavily setulated on both margins and subequal in length to the last two abdominal segments.

Description of female

Length 13.9 mm. Antenna I almost twice the length of the eye and eye stalk (Fig. 1G). Antenna II (Fig. 1G) equal in length to antenna I. Foliaceous, about twice as long as wide and ending in a narrow, sharp protrusion from a shouldered distal portion. Numerous small thin setae on the distal margin. Brood pouch (Fig. 1H) extending posteriorly over a little more than four abdominal segments. Distal part curved away from abdomen and with a small neck before the ovipore. Thoracopods similar to those of male, but knobs on the bases of endopodite setae not as well developed. Cercopods as in the male.

Description of other material

Length variable but around 10–15 mm in males and slightly smaller in females (Table 1).

The frontal appendage of the male in life can be opened into a large sheet considerably wider than the body and about the length of the thorax. Trunk of frontal appendage with 2–5 (usually 3–4) papillae on lateral margins. Outer distal corners of each branch of frontal appendage with 5–

Table 1. Length (mean±SD) of *Branchinella budjiti* from different localities. Ten males and ten females from each locality measured, except entry marked (a): only 7 specimens measured.

locality	length of ♂♂	length of ♀♀
RA Pan, Currawinya NP (Dec 96)	9.7±1.0 mm	8.5±0.8 mm
RC Pan, Currawinya NP (Jun 99)	14.6±0.9 mm	13.0±1.8 mm
Sues Pan, Bloodwood (May 98)	15.3±1.2 mm	14.7±0.8 mm ^a
Goat Pan, Muella (Jun 99)	14.2±1.0 mm	12.6±0.9 mm

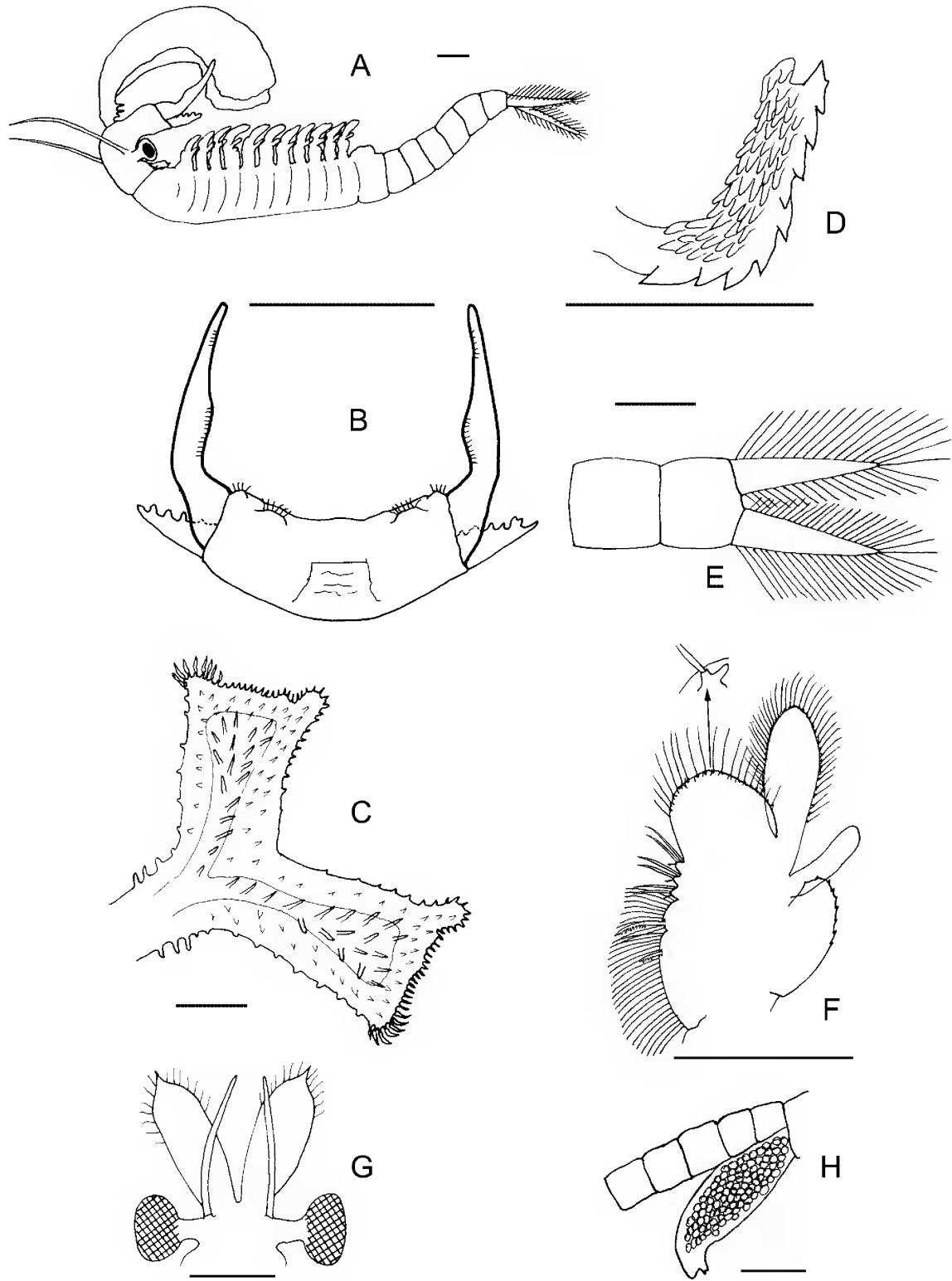


Figure 1. *Branchinella budjiti* n.sp. Male holotype A–F, female allotype G and H. A, lateral view of whole animal; B, dorsal view of antenna II with frontal appendage removed; C, ventral view of frontal appendage; D, penis; E, telson and cercopods; F, anterior view of right 5th phyllopod; G, dorsal view of head, antennae I and II; H, lateral view brood pouch and associated abdominal segments. Each scale bar represents 1 mm.

8 longer papillae. Papillae on lateral margins and lower surface variable in density between specimens, though they are always sparest on the ventral areas of the fused trunk and inner area of branches and most numerous towards the outer distal corners.

Endites 3–5 of thoracopods normally bear 2 setae but sometimes only one is present and this occurs mostly on endite 5.

In females the size and shape of the brood pouch is variable, with the length varying between four and five abdominal segments and the small neck before the ovipore sometimes absent.

Differential diagnosis

In Geddes' (1981) key to Australian species of *Branchinella*, *B. budjiti* straddles both halves of couplet 9, so it needs to be separated the step beforehand—after couplet 7 part 2 (basal segments of antenna II with medial swellings or outgrowths elsewhere). This can be achieved by adding a couplet:

- Trunk of frontal appendage shorter than branches, branches flattened, large and with many papillae, especially on posterolateral margin *B. budjiti*
- Trunk of frontal appendage longer than branches and if branches expanded distally, then relatively small and no concentration of papillae on posterolateral margin 9

The only species likely to be confused with *B. budjiti* is *B. denticulata* from Kalgoorlie, Western Australia. Both have a lamellar outgrowth from the posterodistal corner of the basal segment of antenna II (not the anterodistal corner in *B. denticulata* as shown in Linder [1941] and Geddes [1981]), and both have the two branches of the frontal appendage expanded distally. However, the lamellar outgrowth in *B. budjiti* always has a markedly serrate anterior margin (with 4–6 serrations), but in *B. denticulata* the anterior margin is weakly serrate (with c. 2 serrations) as shown in Linder (1941) and repeated in Geddes (1981) and as seen in the paratypes (C. Rogers, pers. comm.). Furthermore, the lamellar outgrowth is carried parallel to the axis of the basal segment in *B. budjiti*, but in *B. denticulata* its position is variable, either at right angles (as reported by Linder [1941] and repeated by Geddes [1981]), or parallel with the axis of the basal segment (C. Rogers, pers. comm.). It is possible that this variation in position of the lamellar outgrowth is an artifact due to preservation; how the lamellar outgrowth is carried in life is unknown. The frontal appendages of the two species are also superficially similar, but in *B. budjiti* the trunk is short and the two branches much longer, while the reverse applies in *B. denticulata*. The diagram of *B. denticulata* in Linder (1941) and repeated by Geddes (1981) is unrepresentative, showing perhaps a juvenile specimen, since adults among the paratypes examined by C. Rogers (pers. comm.), have the branches more expanded and with papillae on the edges

and some denticles or spines scattered over the dorsal surface. The difference between the two species in the branches of the frontal appendage lies in much greater relative size and the larger number of posterolateral papillae in *B. budjiti*. Further differences between the two species are in antenna II in the adornment of the basal segment and in the shape of the second segment. In *B. denticulata* the basal segment has a few papillae scattered on its medial upper surface and the second segment is evenly arched and lacks any thickening along its length. By contrast in *B. budjiti* there are two medial distal swellings bearing hairs on the basal segment and the second segment has a medial swelling and is unevenly bent at this point. In conclusion the two species seem closely related, but are distinctly different in many key features.

Distribution and habitat

Widespread and common in temporary turbid waters in the middle portion of the Paroo catchment in northwestern NSW and southwestern Qld (Sanders, 1999). The most common habitat is a very turbid (Secchi disc depth <5 cm) claypan that holds water for a month or two after filling (Sanders, 1999; Timms, 1997).

Branchinella campbelli n.sp.

Fig. 2

Type material. HOLOTYPE: ♂, AM P58547, length 12.4 mm; ALLOTYPE: 1 ♀, AM P58548, length 15.4 mm; PARATYPES: 10 ♂♂ (length 12.2±0.6 mm), 10 ♀♀ (length 13.0±1.2 mm), AM P58549.

Type locality. Lake Muella, Tredega Station, 140 km NW Bourke, NSW, 29°31'S 144°53'E, altitude c. 119 m a.s.l. Collected by the author 17 November 1999.

Other material. Five males and three females from Carters swamp, 12 km N of homestead, Muella Station, 130 km NW of Bourke, NSW, AM P58550. Collections by the author from five localities, some on multiple occasions, during 1995–2000 on Bloodwood, Muella and Tredega Stations, 130–150 km NW Bourke.

Etymology. Named for Steve Campbell, Manager of Muella Station for many years.

Description of male

Length 12.4 mm. Cephalothorax slightly longer than the abdomen minus the cercopods. Antenna I a little longer than the basal segment of antenna II (Fig. 2A). Antenna II (Fig. 2A) of normal relative size and angle of repose (c. 20–40° to body axis) for *Branchinella*. Bases fused for almost half their length. Basal segment with a well defined mound about one-third of the way along the free inner surface. Mound clothed with numerous very short thin setae. Apical segment about equal in length to the basal joint, curved and tapering to a wide point. For much of its length the inner surface bears numerous weakly developed transverse ridges.

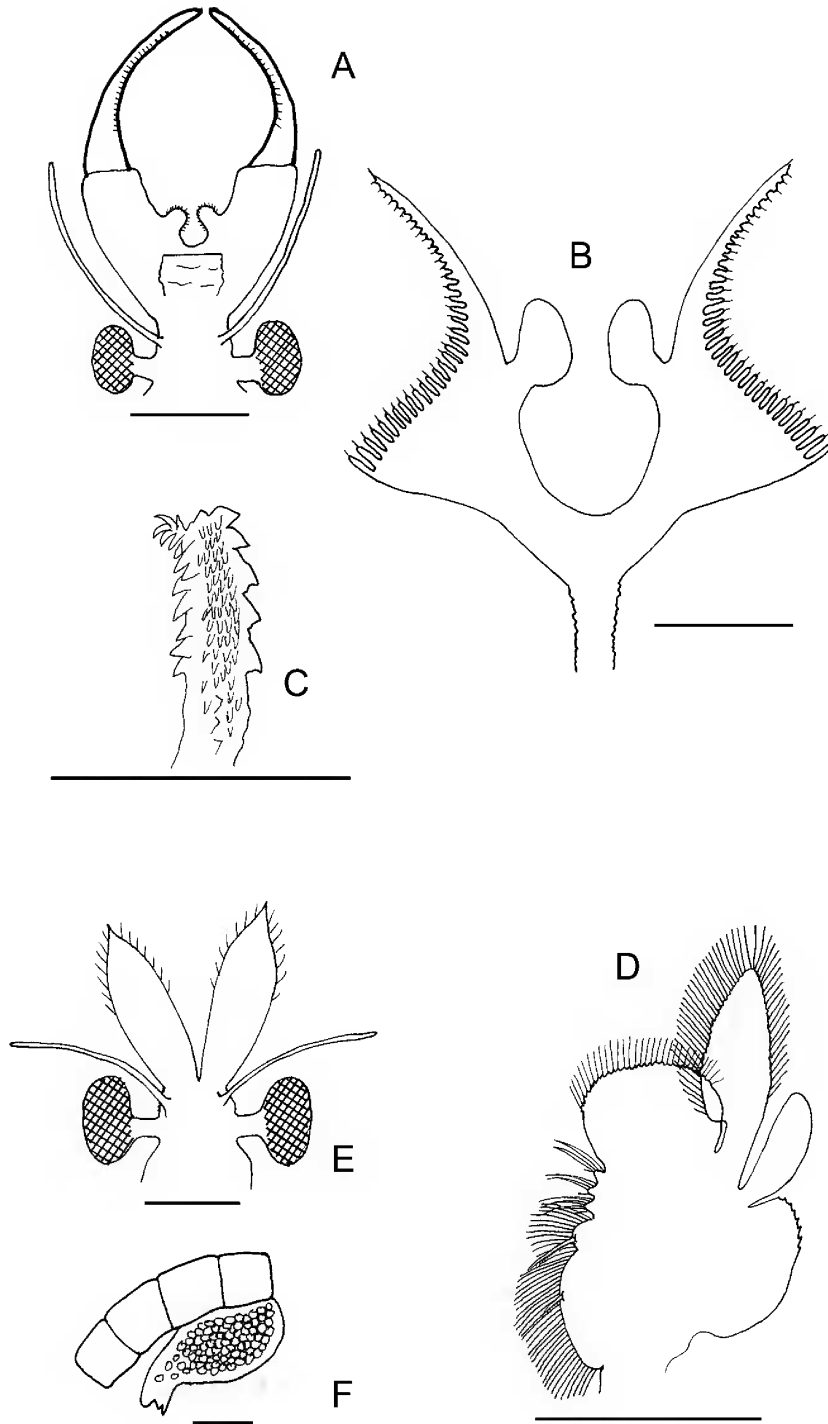


Figure 2. *Branchinella campbelli* n.sp. Male holotype A–D, female allotype E and F. A, dorsal view of head, antennae I and II with frontal appendage removed; B, dorsal view of frontal appendage; C, penis; D, anterior view of right 5th phyllopod; E, dorsal view of head, antennae I and II; F, lateral view of brood pouch and associated abdominal segments. Each scale bar represents 1 mm.

Frontal appendage (Fig. 2B) moderately large and elaborate, approximately equal in bulk to antennae II proper and reaching almost half way along the cephalothorax. Basal section fused into an unadorned trunk, though the trunk is

ringed. Terminal branch with an unadorned flange protruding medially and attached by a wide stem to the inner margin about two-fifths along its length; and expanded basolaterally into a roughly equilateral triangle tapering

distally into a long flagellum-like process. The outer margin of the expanded base and flagellum bordered with finger-like papillae, each terminating in a spine. These papillae number c. 35. The first 20 papillae of similar size, but those towards the tip of the flagellum decrease in size until the last few are swellings rather than papillae.

Fifth thoracopod (Fig. 2D) with endopodite broadly rounded and bearing numerous setae. No knobs on the bases of endopodite setae. Endites 1 and 2 heavily setulated and each with a stout anterior seta, the first about half the length of the second. Endite 3 and 4 with 2 anterior setae and endite 5 with one anterior seta. Exite much longer than endopodite, narrow and with many more and longer setae than endopodite. Epipodite sausage-shaped and smooth. Preepipodite expanded and with a few small sharp denticles on its distal border; no notch on this border. Thoracopods 1 and 11 essentially similar to 5th thoracopod, but smaller and slightly different in proportions.

Penis (Fig. 2C) short, extending back one abdominal segment when everted. Armed on the outer lateral (convex) side with about five broadly based asymmetrical teeth and on the medial (concave) side with numerous (c. 15–21) sharp teeth crowded distally. Innerside teeth more symmetrical, but curved, particularly those near the tip of the penis. Area between the two sets of teeth with thin papillae and some weakly developed, broad-based teeth. No swelling lateral to the penes.

Telson with cercopods heavily setulated on both margins. Cercopods equal in length to the last two abdominal segments.

Description of female

Length 15.4 mm. Antenna I (Fig. 2E) about one and three-quarters the length of the eye and eye stalk. Antenna II (Fig. 2E) equal in length to antenna I, foliaceous, almost three times as long as wide and tapering to a sharp protrusion distally. Numerous small thin setae on the distal margin. Brood pouch (Fig. 2F) deep-bodied and extending backwards over almost four abdominal segments. Thoracopods and cercopods as in the male.

Description of other material

Length variable between 8 and 15 mm (Table 2).

In live males the long apical flagellum of the frontal appendage reaches three quarters the length of the cephalothorax and the basolateral part of the side branches reach somewhat beyond (by a factor of one and a half) the cephalothorax. In many mature specimens this basolateral expansion of the side branches protrudes at its distal corner to make another flagellum-like process, but not as long as the apical process.

Differential diagnosis

In Geddes' (1981) key to Australian species of *Branchinella*, *B. campbelli* keys to couplet 11, but neither alternative offered in this couplet is applicable. An additional couplet is needed after couplet 10:

- Frontal appendage with two simple branches 11
- Frontal appendage with each branch having medially directed flange and a large triangular expansion basolaterally *B. campbelli*

Branchinella pinnata and to a lesser extent *B. frondosa* and *B. arborea* are the species most like *B. campbelli*, all bearing ramification (fine branches of each main branch) of the frontal appendages. In *B. frondosa* and *B. arborea* many of these sub-branches of the frontal appendage are further branched (secondary ramification) whereas in *B. pinnata* and *B. campbelli* all sub-branches are whole. In *B. pinnata* most sub-branches of each branch are long and some are placed on the upper inner surface of each main branch. However in *B. campbelli* each sub-branch is very short and papilla-like (so much so that they do not seem to be the main structure of the frontal appendage as when they are long in *B. pinnata*, *B. arborea* and *B. frondosa*). *Branchinella campbelli* therefore should not key to these species in couplet 5 of Geddes' key. Also none of the sub-

Table 2. Length (mean±SD) of *Branchinella campbelli* from different localities. Number of specimens measured in brackets.

locality and date	length of ♂♂	length of ♀♀
Lower Crescent Pool (Bloodwood) (Oct 96)	15.0 mm (1)	18.0 mm (1)
Carters Swamp (Dec 97)	8.0±0.0 mm (2)	8.7±0.4 mm (6)
Lake Mueller (Jun 98)	11.9±1.6 mm (9)	14.0±0.2 mm (4)
Carrols Swamp (Jun 99)	9.2±0.8 mm (6)	10.2±1.0 mm (5)

branches/papillae is placed on the inner surface of the two main branches in *B. campbelli*. Furthermore, this species has an inwardly directed flange along the medial surface of each branch and a large triangular expansion basolaterally on each branch. A further distinguishing feature between the two species is the presence of a spine at the distal end of the first segment of antenna II in *B. pinnata*.

Distribution and habitat

Restricted to a small area about 50 km² on Bloodwood, Muella and Tredega Stations, 130–150 km NW of Bourke, NSW. It is generally found in temporary clear-water wetlands with few macrophytes in the water column, but occasionally occurs in limited numbers in creek pools where it is probably washed in from wetlands elsewhere (Sanders, 1999).

Discussion

These two species are distinctive and easily distinguished from other Australian species of *Branchinella*. In *B. budjiti* the placement of the basal segments of antennae II at almost right angles to the body axis is characteristic, though a few other species, particularly *B. affinis*, approach this arrangement. Furthermore the lamellar outgrowth at the posterobasal corner of the basal joint is an uncommon feature, as is the large sheet-like frontal appendage. *Branchinella campbelli* is equally remarkable by virtue of its elaborate frontal organ, which has no close counterpart in other species. Certainly the flange protruding medially along the inner margin of each branch and the plate-like basal expansion with all its finger-like papillae are unique. Females of both species, like most in *Branchinella*, are unremarkable.

It is difficult to accommodate either species into any of the three groups of *Branchinella* erected by Geddes (1981). Certainly neither fit into his group I (*B. australiensis*, *B. occidentalis*, *B. compacta*, *B. nichollsi*, *B. buchananensis*, *B. hattahensis*) which are large, sturdy bodied, and males have lateral swellings to the penes and females have a long antenna II. Thoracopods have elongated distal endites only sparsely setulated medially and there are large numbers (10–20) of anterior setae on endites 3–5 of thoracopod 1. Both of the new species are of small to medium size (<15 mm), have a rounded distal endite, endites 3–5 with few (<3) anterior setae, no lateral swelling to the penes in males, and short antenna II in females.

Group II (*B. affinis*, *B. apophysata*, *B. denticulata*, *B. latzi*, *B. longirostris*, *B. probiscida*) animals are small to medium in size, with short distal endites, 2–4 anterior setae on endites 3–5 of thoracopod I, a frontal appendage consisting of a long trunk and two (usually simple) branches, and swellings lateral to the penes (Geddes, 1981). *Branchinella budjiti* has some affinities with this group by reason of small size, the gross structure of the frontal appendage, short distal endite and presence of 2–3 anterior setae on endites 3–5 of the cercopods. However it lacks lateral swellings to the penes, and the frontal appendage has a short trunk and greatly expanded branches.

Likewise *B. campbelli* shares many features with Group III (*B. arborea*, *B. basispina*, *B. dubia*, *B. frondosa*, *B. pinnata*, *B. wellardi*) such as frontal appendage complexly branched, no swellings lateral to the penes, absence of spines on the basal part of the penis, and endites 3–5 of thoracopod I with 2–7 anterior setae. Even so, endites 3–5 are small and not particularly bubble-like, and the animal is small compared to many other species in the group.

Two species (*B. lyrifera* and *B. simplex*) do not fit Geddes' groupings. Probably *B. budjiti* also should be ungrouped but it has some affinities with Group II, especially with *B. denticulata*, while *B. campbelli* is perhaps best considered a non-core member of Group III.

Branchinella budjiti is the sixth Australian *Branchinella* with an outgrowth from the distal end of the basal joint of antennae II. In *B. nichollsi*, *B. hattahensis* and *B. buchananensis* the outgrowth is from the inner corner and is about as long as the second segment (see Geddes, 1981: fig. 5a,b,c). Relative development of lateral papillae varies between the three species, from none in *B. hattahensis*, to a few papillae on the medial side in *B. nichollsi*, to many papillae on the lateral side in *B. buchananensis* (Geddes, 1981). In *B. budjiti* and *B. denticulata* the lamellar outgrowth is smaller and protrudes from the posterodistal corner. There are minor differences between the two species in its structure and angle of repose (see "Differential Diagnosis"). *Branchinella apophysata* also has a lamellar outgrowth of moderate length from the distal end of the first segment (Geddes, 1981: fig. 8f) but insufficient is known on its detailed structure for further comments to be made. In summary it seems that the outgrowths in *B. nichollsi*, *B. hattahensis* and *B. buchananensis* may be homologous (which is supported by Geddes considering them as subspecies within *B. nichollsi*), and those in *B. denticulata* and *B. budjiti* are quite different but perhaps also homologous. The outgrowth of *B. apophysata* may have some affinities with those in *B. budjiti* and *B. denticulata*. Interestingly, the first three species are placed in Group I and the second three in or near to Group II, showing that lamellar outgrowths are not basic features in the classification of *Branchinella* into groups, though the detail of the outgrowth may be of some value. Neither are lamellar outgrowths important generic determinants, for besides being found in some *Branchinella*, they occur in the related genus *Thamnocephalus* (Moore & Young, 1964).

The relationships among Australian *Branchinella* are further clouded by another character, a medial swelling on the basal joint of the second antennae, shared between otherwise unrelated species. Such a swelling occurs in both of the new species and in five other species shared between all three groups (*B. australiensis*, *B. compacta*, *B. probiscida*, *B. affinis* and *B. arborea*) as well as one (*B. lyrifera*) that does not fit into Geddes' groups. The swellings take different forms and are probably not homologous—those in *B. campbelli* are large and bulbous and look like the swellings in *B. affinis* and *B. lyrifera*, while those in *B. budjiti* are simply raised pads with thin setae, perhaps like those of *B. arborea*. These similarities cross Geddes' groupings (*B. campbelli* is similar to a Group II species and an ungrouped species, while *B. budjiti* is included with

a Group III species). Because of these problems and others mentioned by Geddes (1981) meaningful grouping and phylogeny of Australian *Branchinella* probably cannot be achieved by conventional analysis, but DNA sequencing should be useful and is in progress (Hebert & Timms, in prep.)

Finally it is pertinent to note that while *B. budjiti* has a wide distribution within the Paroo, *B. campbelli* occurs in a very limited area (c. 50 km²) despite searching over 3,000 collections over 13 years in the Paroo and adjacent areas. Given that nine species are known only from their type locality (*B. apophysata*, *B. basispina*, *B. hattahensis*) or from a very limited area (*B. buchananensis*, *B. campbelli*, *B. denticulata*, *B. nicholli*, *B. simplex*, *B. wellardi*), all in the arid zone (Geddes, 1981), it is possible that more species of *Branchinella* await discovery in remote areas of Australia.

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